The Supraorbital Endoscopic Approach for Aneurysms

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Key words
- Intracranial aneurysms
- Keyhole neurosurgery
- Minimally invasive neurosurgery
- Supraorbital craniotomy
- Transcranial endoscope-assisted microneurosurgery

Abbreviations and Acronyms
ISAT: International Subarachnoid Aneurysm Trial
MCA: Middle cerebral artery
mRS: Modified Rankin scale
TEAM: Transcranial endoscope-assisted microneurosurgery

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■ OBJECTIVE: **To review our surgical experience in minimally invasive transcranial endoscope-assisted microsurgical treatment of intracranial aneurysms, using the supraorbital keyhole craniotomy.**

■ METHODS: **The supraorbital keyhole approach was performed through an eyebrow skin incision in 793 cases for treatment of 989 intracranial aneurysms. Of patients, 474 were operated on after subarachnoid hemorrhage, and 319 were operated on under elective conditions. After lateral frontobasal burr hole trephination, a limited subfrontal craniotomy was created. To achieve adequate intraoperative exposure through the limited approach, endoscopes were used routinely. Surgical outcome was assessed using the modified Rankin scale.**

■ RESULTS: **The transcranial endoscope-assisted microneurosurgery technique was used routinely via a supraorbital approach. In 152 operations (19.1%), the endoscope provided important visual information in the vicinity of the aneurysm, revealing subsequent clip repositioning. The results of incidental aneurysms were excellent with a modified Rankin scale score ≤2 in 96.52%. The overall outcome of ruptured aneurysms was good with a modified Rankin scale score ≤2 in 72.2% of patients. There were no approach-related intraoperative or postoperative complications.**

■ CONCLUSIONS: **The minimally invasive supraorbital keyhole approach allowed safe surgical treatment of intracranial aneurysms, including after subarachnoid hemorrhage. The markedly improved endoscopic visualization increased the assessment of clip placement with ideal control of surrounding vessels including perforators for identification of incorrect clip position.**

INTRODUCTION

The initial data from the International Subarachnoid Aneurysm Trial (ISAT) published in 2002 showed a significant superiority of endovascular coiling compared with surgical clipping as defined by the proportion of patients dead or disabled at 1 year in a carefully selected group of patients deemed suitable for either therapy (31). The results of this randomized, prospective, international controlled trial represented a landmark and radical change in the treatment of intracranial aneurysms (6, 9, 10, 28, 32, 33, 48).

This significant superiority of interventional therapy is difficult to comprehend from a surgical point of view, particularly after comparison of both methods. Using surgical exposure, operative removal of blood clots with rinsing and cleaning of the subarachnoid spaces may decrease the risk of cerebral vasospasm and chronic hydrocephalus (14, 17, 20-22, 24, 29, 43, 46, 47, 53). With an additional opening of the lamina terminalis, the intracranial cerebrospinal fluid circulation also can be effectively improved (3, 27, 45). An operative approach allows adequate optical exposure of the individual anatomy of the aneurysm, with safe assessment of perforators and neighboring neurovascular structures (29, 33). In the case of rerupture of the aneurysm, immediate control of bleeding is possible (19). In addition, surgical clipping of the aneurysm offers a high reconstructive capacity of the vessel and high reliability of the occlusion resulting in minimal risk of postoperative rebleeding (39). Interventional therapy cannot offer careful exploration of the subarachnoid spaces or the aneurysm. Several cases of insufficient aneurysm occlusion and postinterventional aneurysm recanalization were reported associated with increased risk of rebleeding (8, 33, 44, 49).

Nevertheless, operative therapy requires a surgical approach involving manipulation and retraction of the cortical surface and functionally relevant neurovascular structures. Almost all neurosurgical centers included in ISAT used standard microneurosurgical approaches to treat the ruptured aneurysm (31). We hypothesize that the reason for the significant superiority of endovascular coiling compared with surgical therapy in ISAT was the surgical morbidity and mortality of “standard,” large surgical approaches that were usually employed in this study (12). We believe that operative clipping as treatment of intracranial aneurysms can be improved if surgeons are able to reduce its approach-related complications allowing minimally invasive and maximally effective aneurysm closure. The most effective solution for reducing intraoperative manipulation and retraction is the use of minimally invasive keyhole approaches in neurosurgery (7, 11, 23, 30, 35-38, 41, 49). However, marked reduction of the craniotomy size may result in different shortcomings during the procedure (39).

Because of the predefined direction of the operative exposure, the surgical corridor cannot be changed intraoperatively. Preoperative planning of the approach, including 1) thorough evaluation of preoperative diagnostic imaging of the lesion with respect to the individual anatomy of the patient, 2) definition of the size and site of the tailored craniotomy, 3) positioning of the patient according to the planned surgical corridor, and 4) skin-to-skin performance of the exact approach, is of particular importance in keyhole surgery of intracranial aneurysms (11, 12, 37, 46). An additional problem is the application and maneuverability of conventional instruments; the use of such instruments becomes limited if the size of the craniotomy is <15 mm (**Figure 1**). The application of special keyhole-adapted slender microsurgical instruments (e.g., clip appliers, scissors, suction devices) can effectively resolve this shortcoming (13, 35-37, 39, 42).

The most important disadvantage of small, less invasive keyhole approaches is the loss of intraoperative light and sight causing significantly reduced optical control during surgery (39). For the purpose of bringing light into the surgical field, the optical properties of surgical microscopes can be effectively supplemented by the intraoperative use of endoscopes (5, 7, 11-13, 15, 19, 23, 30, 37-39, 49). The main advantages of endoscopes are the increased light intensity, broadening of the viewing angles, enlarged focus range, and clear depiction of pathoanatomic details in close-up positions (**Figure 2**).

Figure 2. Transcranial endoscope-assisted microneurosurgery—TEAM-work between microscope and endoscope.

MATERIALS AND METHODS

We retrospectively evaluated 793 consecutive cases of intracranial aneurysms operated through a supraorbital keyhole craniotomy. There were 269 male patients and 524 female patients; patient age ranged from 14—82 years (mean age, 51.8 years). Of procedures, 474 were performed following an acute subarachnoid hemorrhage, and 319 were performed on patients with aneurysms that were found incidentally.

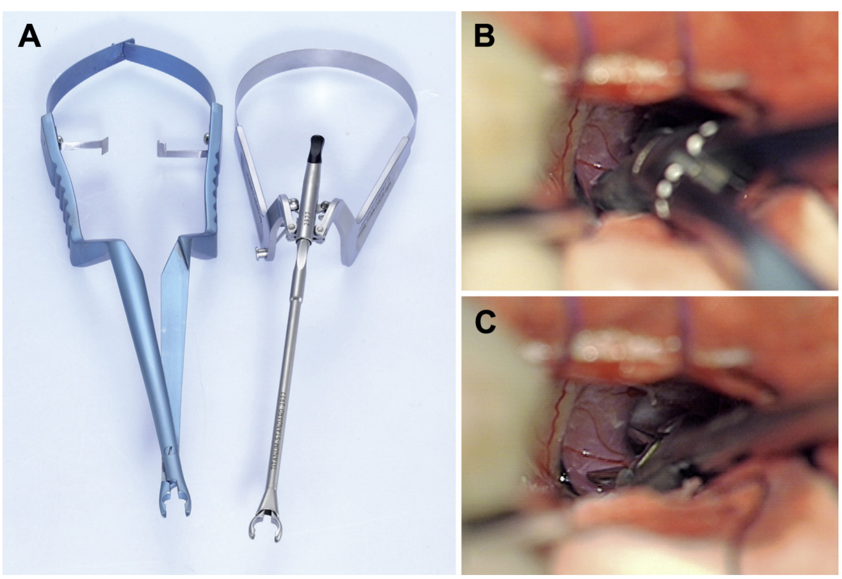

Figure 1. (**A**) Photograph comparing a conventional (*left*) and slender-type clip applier (Aesculap AG, Tuttlingen, Germany). (**B**) When used in keyhole conditions, the conventional instrument cannot be maneuvered, and placement of the clip is not controllable. (**C**) The tube shaft applier can be used within the narrow corridor; the jaws of the clip are well seen allowing safe aneurysm closure.

After interdisciplinary discussion with the interventional neuroradiologist, surgical treatment was chosen when endovascular coiling was deemed technically not feasible. In every case, the surgical approach was determined after careful preoperative study of diagnostic images to determine the least traumatic access to the lesion taking into consideration the individual anatomy of the patient. To improve intraoperative visualization and optical control during surgical manipulation, we routinely used the technique of transcranial endoscope-assisted microneurosurgery (TEAM). The endoscopic imaging was evaluated with respect to the different routes that are available for the endoscope (e.g., the space between the eloquent neurovascular structures). The endoscopes were used for 1) intraoperative anatomic orientation, 2) assessment of the individual anatomy of the aneurysm including small perforators, and 3) control of clip position including the evaluation of neck occlusion or reconstructive capacity of the clip.

Supraorbital Keyhole Technique

After positioning the patient supine, anatomic landmarks of the frontal area, such as the supraorbital foramen, temporal line, level of the frontal cranial base, impression of the sylvian fissure, and zygomatic arch, are determined. Based on this careful anatomic surface orientation, the borders of the craniotomy and placement of the individual skin incision are defined.

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